ROYAL ASTRONOMICAL SOCIETY.

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MANUEL J. JOHNSON, Esq., President, in the Chair.

Frederick John Evans, Esq. R.N., Superintendent of the Compass Department, Admiralty,

was balloted for and duly elected a Fellow of the Society.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, chiefly in the Month of November, 1856.

(*Communicated by the Astronomer Royal.*)

Melpomene.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 8 11 10 20·9	2 23 36·70	96 57 58·84
14 10 42 50·0	2 19 40·56	97 5 29·91
27 9 46 13·8	2 14 10·39	96 32 0·57
29 9 37 58·1	2 13 46·46	96 21 58·45

Fortuna.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 14 8 23 26·8	0 9 56·14	88 35 25·08
27 7 47 8·0	0 14 44·99	88 18 2·15

Eunomia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 14 8 50 38·8	0 27 11·01	65 50 48·67
27 8 1 51·4	0 29 30·80	67 26 37·57
29 7 54 51·2	0 30 22·60	67 39 7·40
Dec. 3 7 41 12·8	0 32 28·10	68 1 56·79

Massilia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 14 10 49 40·9	2 26 32·60	75 53 46·23
29 9 39 35·9	2 15 24·53	76 54 14·52
Dec. 1 9 30 42·6	2 14 22·85	.....

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 5 13 14 9·9	4 15 56·34	59 37 56·71
14 12 30 1·6	4 7 9·78	59 33 43·83
27 11 24 40·4	3 52 53·16	59 51 3·79
28 11 19(39·3)	.....	59 53 26·88
29 11 14 38·8	3 50 43·03	59 55 57·95
Dec. 1 11 4 39·1	3 48 34·76	60 1 20·78

Lutetia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 5 14 5 7·2	5 7 2·03	68 26 35·22
28 12 12 (58·8)	.....	68 32 51·42
29 12 7 59·8	4 44 12·73	.....

It is very doubtful whether any of the above places are those of the planet *Lutetia*.

Note accompanying Drawings of Jupiter, Mars, &c.
By Wm. Huggins, Esq.

"I send herewith two drawings of *Jupiter* for Oct. 14th and 15th. On each occasion the planet was watched for a considerable time, but no change of appearance or of relative position was observed in the markings on the belts, except that due to *Jupiter's* rotation.

"Also, two drawings of the planet *Mars* for April 28th and May 19th.

"Also, a coloured drawing of the lunar eclipse of Oct. 13th, 1856, to show the *deep blue* colour of the *edge* of the umbra, which, for a short time before and after the greatest observation, was in strong contrast with the copper colour of the remainder of the Moon's surface. Gleams of silver-grey light were noticed from time to time to light up partially the dark-blue edge of the umbra. They appeared as if thrown very obliquely upon the Moon from the east.

"*Upper Tulse Hill.*"

On Variable Stars. By Norman Pogson, Esq.

(*Communicated by the President.*)

The ready response which the proposal for a division of labour in the case of observations of the small planets has recently met with, induces me to hope that a similar arrangement may be made with equal facility for the variable stars. Little is yet known of many of these curious objects, in consequence of the small number of observers who have devoted their time to the subject, and it is only by continuous observations that we can expect to trace to fixed laws the often capricious changes which some of these bodies undergo. To facilitate such observations during the ensuing year, I have deduced, from the best available sources, the most probable times of maxima of most of the long-period variables, also the conveniently observable minima of six short-period stars. I have been obliged to omit many of the former class, and even the well-known variable β *Lyræ*, for want of trustworthy elements on which to base their ephemerides. Most of the minima of S *Cancri* in 1857 will, unfortunately, occur at very inconvenient hours. I am indebted to Joseph Baxendell, Esq., of Manchester, for the periods and epochs of the two variables discovered by him, viz. λ *Tauri* and 13 *Lyræ*.

Professors Argelander and Heis, Dr. Schoenfeld, and M. Schmidt, appear to have occupied themselves mostly with the older variables, especially with o *Ceti*, *Algol*, ε *Aurigæ*, ζ *Gemi-*

norum, S *Cancri*, R *Virginis*, α *Herculis*, β *Lyræ*, χ *Cygni*, and δ *Cephei*. Some time since Professor Oudemans signified his intention of watching the telescopic variables discovered by Mr. Hind. Doubtless he will also take care of his own recent discovery, S *Tauri*, as Dr. Luther has hitherto done of his S *Piscium*. Mr. Baxendell has authorised me to state that he has for some years past observed, and will in future hold himself responsible for observations of λ *Tauri*, α *Herculis*, β *Lyræ*, 13 *Lyræ*, χ *Cygni*, η *Aquilæ*, Herschel's *Garnet Star*, and δ *Cephei*. Lastly, I have adopted as my own charge R, S, T, and U *Geminorum*, R *Leonis*, R and S *Ursæ Majoris*, S *Virginis*, S and R *Ophiuchi*, R *Cygni*, 24 *Cephei* (*Hev.*), and R *Cassiopeiæ*.

While writing upon the subject, I take the opportunity to make the following general remarks:—Very few of the variable stars increase and decrease with equal rapidity; hence the time of maximum cannot be deduced by taking the mean between two dates of equal brightness before and after such maximum. I find the most simple and expeditious method to be that of projection on cross-ruled paper, making the abscissæ represent days, and the ordinates magnitudes, to tenths. A curve traced through observations thus projected gives the best general idea of the march of variation, and of any flexures which may occur in the increase or decrease. With the exception of β *Lyræ*, most of the short-period variable stars are tolerably regular, and vary more rapidly about minimum than near maximum. One star, U *Geminorum*, discovered by Mr. Hind in Dec. 1855, is exceedingly curious. For upwards of 90 days it remains invisible,—increases to maximum (9th mag.) and again disappears in about a fortnight, and a day or two after maximum shows remarkable unsteadiness or twinkling which I have not observed with other variables. Next to U, perhaps S *Geminorum* is the most rapid in its visible changes, and remains invisible for the greatest fraction of its period. Its neighbour, T *Geminorum*, is much slower in its changes, though its whole period is a few days shorter than that of S. R and S *Ursæ Majoris* are remarkably regular as regards time of maximum, though less so in intensity of light. R rises with astonishing rapidity to maximum, but fades away very slowly, while S is the most equal in duration of increase and decrease of any variable I know. Others again are very irregular, especially o *Ceti*, R *Leonis*, S *Virginis*, R *Coronæ*, α *Herculis*, R *Scuti*, and R *Cassiopeiæ*. The star 24 *Cephei* (*Hev.*), if periodical, cannot complete its changes in less than 73 years, which makes it due as a naked-eye star about 1880. It has certainly increased during the last 7 years. The red, or rather scarlet tint, is very decided in many stars at maximum. I have noticed it chiefly in R *Cassiopeiæ*, R *Leonis*, and S *Virginis*, which are all irregular stars: in others, as R *Ursæ Majoris*, R *Cygni*, and U *Geminorum*, no change of colour has been perceived. Some stars which do not disappear are hazy and indistinct at minimum, as if surrounded by a corona, or seen out of focus; others are sharp and point-like at such time. So various

are the appearances presented by these mysterious stars, for whose changes no plausible hypothesis has ever yet been suggested.

Variable Star Maxima in the Year 1857.

Star.	Probable Mag.	Mean Place in 1860. R. A.	Mean Place in 1860. N. P. D.	Date of Maxima.
		h m s	° ′	
T Piscium	9·5	0 24 46	76 20	About the end of July or beginning of Aug.
α Cassiopeiæ....	2	0 32 35	34 14	Jan. 9, Mar. 29, June 16, Sept. 3, Nov. 21.
R Piscium	7·5	1 23 25	87 50	Early in June.
o Ceti.....	2·3	2 12 17	93 37	1856, Dec. 30; 1857, Nov. 30.
R Tauri.....	8	4 20 38	80 9	1856, Dec. 20; 1857, Nov. 10.
R Orionis	9	4 51 22	82 5	Either Jan. 31, or April 23. (Period still uncertain.)
s Aurigæ	3·5	4 51 56	46 23	Feb. 14; Oct. 22.
α Orionis	1	5 47 36	82 37	Early in April, and about middle of October.
R Geminorum ..	7	6 58 56	67 5	Jan. 2; and 1858, Jan. 7.
R Canis Minoris	8	7 1 0	79 45	April or May.
S Geminorum ...	9	7 34 38	66 14	Jan. 5, and Oct. 27.
T Geminorum ...	9	7 40 54	65 55	Aug. 5.
U Geminorum...	9·3	7 46 48	67 38	March 4, and October 15. Only visible for about a fortnight.
R Cancri	6	8 8 57	77 53	February or March.
S Hydræ.....	8·5	8 46 15	86 24	March 19, and Dec. 4.
T Hydræ.....	6·5	8 48 51	98 37	January and September.
R Leonis.....	5	9 40 2	77 55	Near the end of July, and therefore not observable.
R Ursæ Majoris	7·5	10 34 41	20 29	May 14. (Minima, Jan. 19, and Nov. 17.)
R Virginis.....	6·5	12 31 24	82 14	March 25, and Aug. 17.
S Ursæ Majoris	7	12 37 48	28 8	April 20, and Nov. 28. (Minima, Jan. 11, and Aug. 20.)
R Hydræ.....	4	13 22 5	112 33	Possibly early in February, but uncertain.
S Virginis	5·5	13 25 42	96 28	March 29. Changes of colour very decided.
S Serpentis	8	15 15 8	75 11	June 26.
R Coronæ	6	15 42 49	61 25	Very uncertain, but perhaps in May.
R Serpentis.....	6·5	15 44 15	74 26	Nov. 8, and therefore not observable.
S Ophiuchi	9·3	16 26 12	106 53	May 15.
R Ophiuchi.....	8	16 59 44	105 54	October 4.
α Herculis.....	3	17 8 16	75 27	April 14, June 19, August 24, and Oct. 30. Very irregular.
R Scuti	5	18 40 1	95 50	April 18, June 29, and Sept. 8. Also very irregular.
13 Lyræ	4·3	18 51 4	46 14	Jan. 8, Feb. 23, Apr. 11, May 28, July 13, Aug. 29, Oct. 15, and Nov. 30.
R Aquilæ	6·5	18 59 40	81 59	Probably early in August.
R Cygni	8	19 33 4	40 7	Feb. 14. (Minimum, Oct. 23.)
χ Cygni.....	5	19 41 7	56 36	December 27.
R Pegasi	8·5	22 59 38	80 13	August 15.
R Aquarii	7	23 37 15	106 3	July 27.
R Cassiop. (2nd)	6	23 51 18	39 23	1858, Jan. 30. (Minimum, 1857, Aug. 21.)

Minima of Short-period Variable Stars in the year 1857, *for the Earth's Mean Distance from each Star, and Greenwich Mean Times.*

Algol. Max. 2·3. Min. 4·0.			λ Tauri. Max. 4·0. Min. 4·5.			η Aquilæ. Max. 3·6. Min. 4·4.		
	h	m		h	m		h	m
Jan. 2	9	28	Feb. 4	12	37	May 3	13	59
5	6	17	8	11	29	June 8	11	9
19	14	21	12	10	21	July 21	12	32
22	11	10	16	9	13	Aug. 26	9	42
25	7	59	20	8	5	Sept. 2	13	55
Feb. 11	12	52	Oct. 7	14	9	Oct. 8	11	5
14	9	41	11	13	1	Nov. 13	8	14
March 6	11	23	15	11	53	Dec. 19	5	24
9	8	12	19	10	44			
29	9	54	23	9	36	ζ Geminorum. Max. 3·8. Min. 4·5.		
April 21	8	25	27	8	28			
May 28	15	0	31	7	20		h	m
June 20	13	31				Jan. 16	8	1
July 13	12	2	δ Cephei. Max. 3·7. Min. 4·8.			26	11	36
Aug. 2	13	44		h	m	Feb. 5	15	11
5	10	33	Jan. 15	14	5	March 28	9	3
25	12	15	26	7	40	April 7	12	38
28	9	4	Feb. 11	10	3	Aug. 27	14	41
Sept. 14	13	57	27	12	26	Oct. 27	12	8
17	10	46	Mar. 15	14	49	Nov. 6	15	42
20	7	35	26	8	24	Dec. 27	9	35
Oct. 7	12	28	April 11	10	47			
10	9	17	27	13	10	S Cancri. R.A. 8h 35m 56s N.P.D. 70° 28′ Max. 8·0. Min. 10·5.		
27	14	10	May 24	9	9			
30	10	59	June 9	11	32			
Nov. 2	7	48	25	13	55		h	m
19	12	41	July 22	9	53	Jan. 16	8	57
22	9	30	Aug. 7	12	16	Feb. 4	8	10
25	6	19	23	14	39	23	7	24
Dec. 9	14	23	Sept. 19	10	37	Dec. 14	7	29
12	11	12	Oct. 5	13	0			
15	8	1	Nov. 1	8	59			
			17	11	22			
			Dec. 3	13	45			
			14	7	20			
			30	9	43			

The observed times of Minima of short-period Variables require to be reduced to what they would have been at the earth's mean distance from the star, to render them comparable with each other, or with the above ephemerides. The following formulæ will supply these corrections, with their proper signs, in minutes of time, for each star; the earth's radius-vector and sun's longitude being denoted by R and ⊙ respectively:—

				m			°	′	
For Algol	...	...	...	7·67	R	sin	(215	47	+ ⊙)
λ Tauri	...	...	...	8·22	R	sin	(211	19	+ ⊙)
δ Cephei	...	...		4·21	R	sin	(254	19	+ ⊙)
η Aquilæ	...	...		7·72	R	sin	(331	31	+ ⊙)
S Cancri	...	...		8·30	R	sin	(143	38	+ ⊙)
ζ Geminorum		...		8·29	R	sin	(166	58	+ ⊙)
β Lyræ	...	...	...	4·64	R	sin	(343	4	+ ⊙)

On the Correction of Observations made with the Sextant. By W. H. Simms, Esq., communicated by William Simms, Esq.

The object of this communication is to demonstrate the practicability of correcting sextant observations for the instrumental error of excentricity;—an error, which probably exists in most sextants, and to such an amount that the maximum correction to an angle read from the arc is seldom less than 30″, and not uncommonly exceeds 1′.

The author commences by investigating the formula for the computation of the correction, the relative position of the centres of the index and arc being given. This relative position depends upon two constants, which enter into the formula: consequently, two or more absolute values of the correction being known, the constants can be determined. Such absolute values can be obtained in any number by comparing the results of observation of distances of well-known stars with their computed distances; or, at a place of which the latitude is known, by observation of meridian altitudes of similar objects. The latter method is undoubtedly the better and more convenient, and may be employed at a place of which the latitude is unknown, the latitude itself being introduced as a third unknown quantity into the equations resulting from the observations.

But, in order that this process may be applied with success, it is evidently necessary that the results of the observations should not be materially affected by any instrumental error other than excentricity. The author accordingly investigates the formulæ for the calculation of the corrections due to the remaining three principal errors to which the sextant is liable, viz. deviations of the planes of the index and horizon glasses, and of the optical axis, from their correct positions with respect to the plane of the instrument;—and shows that, if ordinary care be taken in the

performance of the requisite adjustments, such of these errors as are likely to exist in a good instrument will not sensibly affect the results. The investigation is given at length in the case of an error in the position of the horizon glass, the formulæ only being given in each of the other cases, as well as in a combination of the three; this having been thought sufficient as an indication of the process. The results of these investigations are satisfactory, not only with reference to their immediate object — the demonstration of the fact that excentricity is the only instrumental error which, under ordinary circumstances, produces sensible effects — but as showing that small accidental disturbances of the horizon glass, such as frequently take place in the course of a series of observations, are unimportant, provided they do not affect the index error.

Having shown that the results of observation are sensibly affected by error of excentricity alone, the author proceeds to explain in detail the processes by which the values of the two constants, which enter into the formula for the computation of the correction may be determined; and concludes, by giving examples of their determination, and of the construction of tables of corrections for various positions of the index upon the arc.

A note is appended to the communication containing details relative to the determination of index errors.

On the Latitude of the Liverpool Observatory, deduced from Observations made with a Transit Instrument placed in the Prime Vertical, by means of Formulæ given by W. H. Simms, Esq.

In vol. xiii., No. 8, of the *Monthly Notices* of the Society, is a communication by Mr. Hartnup, on the latitude of the Liverpool Observatory, from observations made with a transit-instrument placed in the prime vertical. The formulæ used for the reduction of the observations, as stated in that paper, were obtained from Mr. W. H. Simms, who was at that time resident at Colombo, in Ceylon.

Mr. Simms, being now in England, has communicated to Mr. Hartnup his investigations in a revised shape, and has given the formula for deviation from the prime vertical in a more convenient form, and, at the same time, has introduced the effect of an error of collimation on the results, which was neglected in his former communication. With these new formulæ, he has calculated the corrections for deviation and collimation for the whole series of observations previously employed in deducing the latitude; and Mr. Hartnup has taken the opportunity of making a fresh determination of this element. The whole number of

transits formerly employed was 58, but of these it has appeared desirable to reject 4; and, from the remaining 54, the latitude deduced by means of the new formulæ is 53° 24′ 47″·40, with a probable error of 0″·10. This result is less by 0″·32 than that given in vol. xiii. of the *Monthly Notices*.

The number of stars employed is sixteen; and, for each of these, Mr. Hartnup has given, in a tabular shape, the values of the constants required in the use of the formulæ; and, in a second table, he has given the individual result derived from every transit of each star, together with the values of the errors of deviation and collimation for each evening, and the corrections which they entail on the results.

This communication, as well as the preceding, will appear in full in the *Memoirs*.

On a Proposed Mode of relieving the Weight of the Moving Portion of an Altazimuth, and on the Theory of the Stability and Pressure exercised by the Upper Works. By Lieut. J. F. Tennant, Bengal Eng., F.R.A.S, First Asst. Gt. Trig. Survey of India.

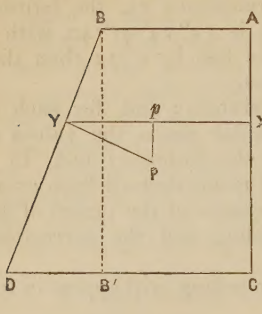
"The form of altazimuth instruments of which I purpose writing, is that in which the whole of the azimuthal axis is below the vertical circle. These are generally supposed to be less stable and less adapted for very accurate observation than those in which the vertical axis is divided and held both at top and bottom, the telescope and vertical circle being between the two supports. My attention has been especially directed to the class of instruments I have named, as that form is alone suited to theodolites for Geodetical operations, and has led to a similar construction of altazimuths for the trigonometrical survey of India.

"Instruments of this form may be subdivided into two classes, of which the first has the axes *turned down* (the acute end down), and the second* has them *turned* up. The former construction allows of a long axis, while the height of the instrument is not increased, and has been employed for this reason, as length of axis appears to ensure steadiness; but I shall, I think, show reason for preferring the second construction, or that with a moderately long turned up axis.

"I purpose first considering the distribution of weight on an axis supposed to be composed of two conical portions, whose vertical angles are different, and shall first investigate the amount of weight which will be supported on a right cone with the axis vertical by a given pressure on each unit of its surface.

* An illustration of this construction will be found in Pearson's *Int. to Practical Ast.*, Plate xix.—Editor.

"Let the accompanying figure represent the trapezoid, by whose revolution about A C the frustrum of a right cone forming the axis is generated. Let



$$A B = a = C B', \qquad C D = b, \qquad A C = l,$$

and the angle $D B B' = d$.

"Also let $A X = x$, $X Y = y$.

"Also let Y P represent the pressure sustained by the element of the surface, whose sides are d (B Y) and $y\, d\, \theta$ (to use the infinitesimal notation).

Now $B Y : A X :: B D : A C :: 1 : \cos \alpha$,

$$\therefore B Y = x \sec \alpha,$$

$$\text{and} \quad d(B Y) = \sec \alpha\, d x.$$

"And if p be the pressure per square unit of surface, then $P Y = p \,.\, y \sec \alpha\, d\, \theta\, d x$, and the resolved part in a vertical direction, or the weight it will support, is

$$P p = P Y \sin \alpha = p \,.\, y \tan \alpha\, d\, \theta\, d x,$$

but if we suppose the whole frustrum to be in action, the supported weight will be

$$\int_0^l \int_0^{2\pi} p \,.\, y \tan \alpha\, d\, \theta\, d x$$

or since $y = x \tan \alpha + a$

$$= \int_0^l \int_0^{2\pi} p \left\{ x \tan^2 \alpha + a \tan \alpha \right\} d\, \theta \,.\, d x,$$

$$= p \int_0^{2\pi} \left(\frac{1}{2} l^2 \tan^2 \alpha + a l \tan \alpha \right) d\, \theta$$

$$= 2 p \pi \left(\frac{l^2}{2} \tan \alpha + a l \right) \tan \alpha$$

But $l \tan \alpha + a = b$, and $l \tan \alpha = b - a$

$$\therefore \text{weight} = p \pi (b + a)(b - a) = \pi (b^2 - a^2)\, p$$

whence if W be the total weight supported by the frustrum, we shall have

$$p = \frac{W}{\pi (b^2 - a^2)}$$

or it will have the same value as it would have were a similar weight supported on the base of the inclined surface in action.

"I have supposed the pressure to be uniformly distributed over the acting surface, which would, I conceive, be the case had we a true mathematical frustrum; and I think this will, in a

well-made axis, be an approximate representation of the case. We are not, however, entitled to consider that, if we have two frustra (the angle β in the second being substituted for α) simultaneously in action, that the pressure on the surfaces will be equal in both.

We can, of course, adjust this to some extent as we may please originally, but the adjustment will only be permanent, if the pressure on the frustrum, the angle of whose cone is 2α (which I shall call the frustrum 2α), be to the pressure on the frustrum 2β in the proportion requisite to ensure wear keeping the same state of fitting. Now, the amount of wear on the frustrum 2α will be to the amount of wear on the frustrum 2β as $\sin\alpha$ to $\sin\beta$, when this state is attained; and if we assume that the wear is proportional to the pressure, an assumption which, in default of positive data, seems to be probable, we shall have

$$P_{\alpha} \text{ (or pressure on frustrum } 2\alpha) : P_{\beta} :: \sin\alpha : \sin\beta$$

" If there be a flange, or $\beta = 90°$,

$$P_{\alpha} : P \text{ on flange} :: \sin\alpha : 1$$

" Let us, on this supposition, assume $p \sin\beta$ as the surplus pressure on the more obtuse cone, then will $p \sin\alpha$ be that on the more acute one; and we shall have, calling A and B the bases of the acting surfaces,

$$p\,A \sin\alpha + p\,B \sin\beta = W, \text{ the free weight,}$$

but P the total pressure causing friction

$$= p \sin\alpha \,.\, A \operatorname{cosec}\alpha + p \sin\beta \,.\, B \operatorname{cosec}\beta \text{ or } p\,(A + B)$$

whence,

$$P = W \frac{A + B}{A \sin\alpha + B \sin\beta}$$

which, when α is a very small angle, as is usual, will very nearly equal W cosec β.

" This explains the theory of the flange and Ramsden's cup in rendering motion free, which would otherwise be so stiff as to be objectionable.

" Keeping in view these principles, we may, from a knowledge of the co-efficient of friction derived from experiment, predict the force which would be sufficient, at the place where the hand is intended to be applied, in moving the instrument to cause it to revolve.

" Where this force is too large, it becomes necessary to relieve a portion of the weight of the moving part. So far as I am aware, this has hitherto been accomplished by springs, and by counterpoising weights acting on levers; friction rollers in each case being the mode of transmitting the action to the upper works. Variable tension at different times, and consequently irregularly applied relief, is an objection to springs; and, moreover, from the

necessary shortness, they generally have to be very stiff, and small differences of compression are correspondent to material pressures. These are avoided by counterpoises, but they add to the weight of the instrument; and where (as in theodolites) the instrument travels, they must be previously removed, of which perhaps the inconvenience can only be appreciated by those who have had to dismantle and pack up instruments late at night, when wearied with a long day's work. In either case, want of power to render the resultant transmitted pressure *axial* is a great objection, and it does not appear that this can be accurately managed.

"It seems absolutely essential to the good performance of an instrument of the class I am examining, that the resultant of the weight of the moving portions and relieving springs should be *axial*, as otherwise there will not be fair action on the axis; and the simplest way of attaining this would appear to be, to make the weight and relieving force each axial separately. I also think that a low position of the centre of gravity, such as will enable it to be *immediately supported* by the axis, and thus secure the instrument against any great tendency to oscillatory motion, is at all events very advisable.

"The weight of a telescope and vertical circle, and the height to which they must be raised to allow of reversion of the telescope, is no doubt an obstacle to carrying out the last principle; but we can still lower the centre of gravity within the axis, by turning up the axis and using a very heavy drum, to which the only objections I know are the want of portability and the difficulty of sufficiently reducing friction. The former is of less importance than the steadiness of the instrument, and the latter, I believe, can generally be sufficiently relieved by the means I am about to mention.

"I propose, then, to adapt to the upper part of the hollow conical axis a shallow reservoir for oil, having a narrow cylindrical tube rising out of it, in which works a piston urged by a weight. The reservoir is to be open downwards, by which pressure will be transmitted by the oil to the head of the solid cone, and the same pressure will assist in lubrication. We may then make this pressure relieve any amount of weight within the limits I shall point out, and at the same time secure its rigorously axial application.

"If the free weight be m W, p the pressure on the unit of the flange, and $p \sin \alpha$, therefore, that on the conical frustrum before the relief is applied, or while the weight is W, then $mp \sin \alpha$ will be the pressure on the relief being given, unless the pressure on a unit of surface on the head of the axis be greater than $mp \sin \alpha$, when the whole surface of the frustrum will come into play, and we must consider the relieving pressure as acting on the area of its base.

"It is quite evident, however, that if q be the relieving pressure on a unit of surface, mp must be $> q$ as a necessary condition

to prevent the expulsion of the oil when the capillary action which retains it is overcome. In cases where there is no flange, the pressure on the unit of surface of the cone will have to exceed that on the head for the same reason, and if the necessary relief cannot be given with the given dimensions of the axis, it can of course in this case be attained by increasing its dimensions.

"How far attention to these principles will secure stability in conjunction with freedom of motion, it is impossible to say without putting them in practice, but I hope soon to have an opportunity of carrying them out in endeavouring to obtain a better azimuthal motion for one of the 3-foot vertical circles belonging to the trigonometrical survey of India, which, though producing results of the highest order, would still admit of an improvement. I am induced to offer these remarks to the Society, in the hope that the hydraulic relief may be an improvement on those previously in use, and that by it a class of instruments in which I am professionally much interested may be rendered more perfect.

"I have not attempted to lay down any rules as to the dimensions of axes or their forms. So many variables are involved in the determination of the best form, and a departure from it to a moderate extent will so little affect the value of instruments, that probably no definite rules could be so valuable as the intuitive perception of the practised artist. I believe, however, the general principles I have here laid down, and the theory to guide their application, will occasionally be found useful, and they may tend to place the form of instrument preferred by Mr. Troughton on equal terms with that chosen by some other makers, by increasing the steadiness without the disadvantage of unequal expansions inseparable probably from the framework required to support an axis at both extremities.

"In the case of the 3-foot circle I propose that the drum pillars and micrometer-supporters should be cast in one piece of iron, and, after being fitted, adjusted so as to have the centre of gravity axial by floating the mass in mercury, and adding or subtracting small weights of metal, as may appear desirable.

"*Masuri, June* 4, 1856."

Notes on the Manufacture of Tubes for Refracting Telescopes. By Frederick Brodie, Esq.

"In the early part of this year I parted with my Munich refractor of $6\frac{1}{3}$ inches clear aperture, and obtained from the Rev. W. R. Dawes his American object-glass, made by Mr. Alvan Clarke, of Boston, U. S., an account of which was published in the *Monthly Notices*, vol. xv. page 79.

"The original tube for this glass was retained by Mr. Dawes for mounting another larger object-glass, by the same maker. It,

therefore, became a matter of consideration with me to procure a tube which should combine strength, rigidity, and lightness, being convinced in my own mind, that the less the weight of the tube (and consequently of its counterbalances), the greater would be the steadiness and freedom from vibration when mounted on its equatoreal stand.

"I was led to this conclusion by the experience which I had had with my $8\frac{1}{2}$-foot Munich refractor, with its light wooden tube, and in which, when fixed on my peculiar equatoreal mounting, I had never found the slightest oscillation or tremor, when moved either by hand or the tangent-screw motion. This great steadiness I attribute to two principal causes:—Firstly, to the loading of the polar axis with as little weight as possible. Secondly, to the fact that the polar axis has comparatively large bearings.* In several mountings of large telescopes that I have seen, where the polar axes have been loaded with brass tubes and heavy circles, and where the bearings (or pivots) have been comparatively small, I have noticed a very considerable amount of oscillation in right ascension.

"After some consideration I determined on constructing the tubes entirely of mahogany veneers; veneers cut from deal would have been lighter than those from mahogany, but they were not considered so trustworthy for this purpose. I placed the execution of this experimental tube in the hands of Mr. Chaffins, of 67 Oxford Street, who carried out my directions satisfactorily.

"This tube was formed upon a core of dry, well-seasoned deal planks, and turned down in the lathe to the following dimensions:—

Length of core	9 ft. 0 in.
Diameter, large end	..... $7\frac{7}{8}$
Do. small end	..... $5\frac{7}{8}$

"The core was well soaped to prevent the possibility of any portion of glue adhering to it, and thereby rendering the removal of the tube difficult when finished. Upon the core a sheet of thick brown paper was wrapped, its edges being pasted together, to serve as a foundation for the first veneer. The core was then brushed over with glue, and a veneer of mahogany laid round it; a moveable caul made of double canvas was then laid round the veneer, and drawn up tightly by means of screws.

"This caul exactly fitted the taper of the tube, and its longitudinal edges were securely fastened to two strips of wood. In one of these strips, at intervals of about 5 inches, were inserted common bed-screws, moving freely through it, and screwing into

* The size of the bearings of the polar axis cited above was as follows:—

Lower bearing	4 inches diameter.
Upper do.	$3\frac{1}{4}$ do.

corresponding nuts in the other strip. By this means the caul was screwed up tightly round the veneer, thereby ensuring a close contact between it and the core.

"The core was then placed over a stove-pipe, which extended along its whole length, and was slowly turned on its axis until it became sufficiently hot to melt the glue, which thus became equalized, while the superabundant quantity was squeezed out; a portion even permeating the veneer, owing to the pressure of the caul. The core was then set aside for two or three days to dry.

"Every successive veneer, prior to being laid on, was lined with a piece of thin calico, to prevent the veneer from splitting while being turned round the core. This calico was removed when the veneer was dry; after which the surface was prepared for another veneer, by being levelled over and freed from inequalities by the veneer plane. Each veneer was in a single piece, the joints being placed at alternate sides of the tube, and the grain of the wood was reversed at every layer. A tube was thus formed of eight thicknesses, the seven interior ones being of Spanish mahogany having stains or other faults which rendered them unfit for *fine* cabinet work, and therefore of moderate cost (about *9d.* per foot super). The eighth was of the finest Spanish mahogany, and cost (on account of its great size) about *1s. 8d.* per foot super. The thickness of tube when finished was $\frac{3}{8}$ of an inch. It was French polished on the outside.

"Since this tube has been finished another tube has been constructed in a similar manner, and sufficiently stiff, of only *six* veneers. The dimensions being,

Length of tube	6 ft.	8 in.
Inside diameter, large end		$6\frac{3}{8}$
Do. small end		$4\frac{3}{4}$

"The tube which was sent over from America by Mr. Alvan Clarke is of a novel construction, it being made of a sheet of zinc covered with brown paper. This tube is still in the possession of Mr. Dawes, and carries an 8-inch object-glass. It is only $\frac{2}{10}$ths of an inch in thickness, but is remarkably solid and hard to the touch.

"The method of making these tubes is thus described by Mr. Clarke in a letter to the Rev. W. R. Dawes:—

"'We made our tube for that (telescope), as we have for others since, of thin tin, overlaid with paper and paste, to a suitable thickness. By drawing a thread from end to end we find out the low parts, and raise them by an extra coat of paper, and at the same time rasp down the higher parts until tolerably straight. We then joint a piece of plank and coat it with wax, and lay sand-paper upon it; with this we dress down the tube preparatory to painting. We give several coats of different tints, blue, red, and yellow, all faint, but of the same depth when dry; they are rubbed down together. The effect is very pleasing to the eye, and I think, under

copal varnish, this tube must be very secure. For the larger object-glass which you have, zinc was used instead of tinned iron.'

"The Munich tubes appear to be made of two thicknesses of light wooden battens, about $2\frac{1}{2}$ inches wide, and of the same length as the tube itself. These battens are laid longitudinally round a core, the inner thickness breaking joint with the outer; over this is laid a veneer of mahogany, which is finally French polished.

"The relative weights and thicknesses of the different tubes are as follows:—

	Thickness of Tube.	Weight of Tube.
Brass or iron tube	0·06 to 0·10	3 to 5 lbs.
		lbs. oz.
Square deal, corners champered off	1·00	2 8
American tube, paper and zinc	0·20	1 $10\frac{1}{2}$
Mahogany tube, 8 veneers thick	0·37	2 1
Do. 6 veneers thick	0·28	1 $8\frac{1}{2}$"

Specimens of the tubes described accompanied the paper.

On the Angular Disturbances of Ships, as affecting Astronomical Observation at Sea. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.*

"Every one who has used a telescope on shore knows the importance of steadiness in its stand; and nearly every one in this nautical country must have experienced in person how ships roll, and pitch, and lurch at sea; upsetting all ideas of stability, even for the ordinary affairs of life, and much more for scientific requirements. On inquiring, however, from even practical men, I have not found them able to give me numerical particulars of the exact amount, and the manner of the occurrence, of these angular disturbances of position, which occur to a ship while pursuing its onward course; and as some knowledge of this is essential before attempting to devise a remedy, we may with propriety first consider the means of obtaining this information.

"*Measurement of the Disturbances.*—All the various angular motions to which any ship is liable, the translation of the whole ship bodily being of no moment here, are reducible to three, viz., —to *rolling*, a motion from side to side; *pitching*, from end to end; and *yawing*, or deviating in azimuth.

"*Old Ship-Clinometers.*—Very ingenious methods have been contrived to fit pendulums to act as ship-clinometers, as in Captain Becher's horizon; wherein the pendulum swings in a vessel of oil. But the result is not satisfactory; for the oil itself is dis-

* Reduced, by permission, from a paper lately presented to the Society of Arts at Edinburgh. The woodcuts have been very kindly lent by the Society.

turbed, and while the pendulum's tendency to vibration is not got rid of, its sensibility to angular motion is impaired.

"Troughton, again, employed a most elegant method; for, constructing a pendulum of a circular form, like an inverted cup, he set this spinning at a great velocity; and then for a time it seemed to bid defiance to any disturbances in the absolute position of what it rested on, while it showed the angular movements well. Soon, however, the defect predicted by an astronomer became practically apparent, viz., that the forces producing vibration in a simple pendulum were still at work in this rotatory one, and these effects compounded into the spinning movement, at length produced precessional disturbances, which entirely destroyed the accuracy of the indication.

"*New Clinometer.*—For ship purposes, then, we need something that shall be barely influenced by horizontal, but shall be very sensible to angular displacement. Now, this necessary quality of sensibility existing, as is well known, to a high degree in spirit-levels, I first tried modifications of these for naval purposes. The bubbles of air were certainly liable to vibrate after the style of the pendulum by linear movements; but they came to rest almost immediately after the disturbing force had ceased; and a little reflection on the reason of their first movement, immediately made me perceive that it might be reduced indefinitely by decreasing the size of the bubble, and this I found true in practice. But then came the difficulty, that with very small air-bubbles the friction or retardation of their movements greatly increased. A series of experiments, however, on different fluids, indicated that with chloroform the desiderated qualities existed in a sufficient degree for practical purposes, the amount of resistance to movement of small bubbles therein being about $\frac{1}{3}$d of that in ether, $\frac{1}{18}$th of alcohol, and $\frac{1}{100}$th of water.

"*Safety-Level.*—There then remained only to contrive some plan of safety, by which, in a hermetically sealed glass tube (for no other will confine chloroform) a very small bubble might be employed, without a chance of fracturing the glass when the liquid should expand at a high temperature. This object has been attained by introducing a pierced diaphragm into the tube

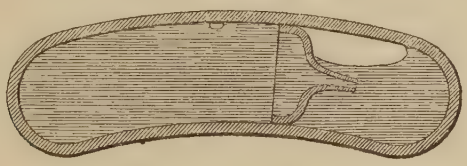


Fig. 1.

Sectional Elevation of the Adjustable Minim Bubble-Level.

near one end, and confining therein a large quantity of air, which serves as a safety-valve for the fluid from the rest of the tube

to press upon when expanding. In ordinary motions of the level, the air does not change its compartment, but when it is held vertical and shaken smartly, small particles of the air may be made to pass from one side to the other of the diaphragm; and thus the bubble may be adjusted in size at pleasure. Mr. John Adie has made many of these levels for me with consummate skill, and finds that to be the best kind of diaphragm or plug which is made of glass and fitted with floss silk.

"*Application to Ship Purposes.*—To apply this principle to a clinometer for use at sea, I have had such a safety chloroform level made to a radius of 6 inches, and an arc of 180 degrees. Being further fitted into a wooden frame with a greyed-glass back, having the angles painted thereon, the smallest bubble is clearly visible, and it will be found to possess, not perfect, but a very high degree of freedom from the effects of horizontal displacement, with, at the same time, an eminent degree of sensibility to angular motion.

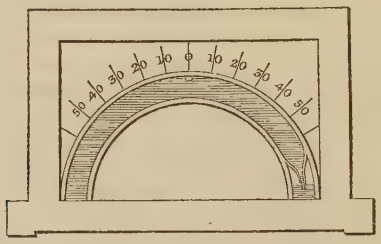


Fig. 2.

Sectional Elevation of the New Ship Clinometer.

"*The Rotation Clinometer.*—The level clinometer, however, does not indicate azimuthal disturbances; and though sufficient and very convenient for most practical purposes, a more perfect instrument is conceivable—one that shall be positively undisturbed by even the most violent lurches, and that shall measure yawing as well as pitching and rolling.

"Such an instrument I have now been able to bring forward, by a proceeding which is equivalent to balancing a Troughton's top, placing it in gimbals, and mounting a second similar apparatus on the top of it with its revolving plane crossing the other at an angle of 90°. But as this machine has resulted from the researches I have been making connected with the *elimination* of a ship's movements, presently to be described, I shall only now say that its action as a *differential* instrument for a short space of time is wonderfully perfect. The rolling is shown on one circle, the pitching on another, and the yawing on a third; and any features in which the level-clinometer may fail, are the strongest points in this instrument. For, while absolutely uninfluenced by horizontal

displacement, however quick, or violent, or unexpected, still it has not thereby its sensibility to angular motion injured in the smallest degree; and, in a word, it may confidently be said to be entirely free from the defects which have been described to exist necessarily, to more or less extent, in all pendulums, fluids, or in gravitation appliances generally.

"*Elimination of the Disturbances. Methods hitherto in vogue.*—When an object, for instance a small table, is to be kept level at sea, there is but one method at present employed, viz., to suspend it freely, either in gimbals like a chronometer, or by strings from a hook, as with the trays over a cuddy-table.

"But plainly by such a proceeding we should not have approached the qualities of a table-stand for astronomical instruments; and as long as we have free suspension of any sort above, and a weight below, we may be sure that our arrangement is but a pendulum, which, as described in the case of the clinometer, must, when at sea, be ever oscillating anomalously; and, therefore, being unable to keep itself steady, it can never on ship-board keep a table so. Yet this was the only principle of Nairne's celebrated observing-chair, which, though rewarded by Government, utterly failed in practice.

"*Neutralization of Vibrations.*—Free suspension, however, of some kind we must have, or our table will be carried over bodily and forcibly with the ship; but let us first try to get rid of oscillations, the effect of horizontal displacements, and afterwards we may more successfully cope with the angular motion. To this end, knowing that a pendulum will swing, we shall find it salutary to hang it from its centre of gravity. Then, with a free suspension still, but with as much matter above as below it, the pendulum is changed into a balanced body; and the lurches of the ship, acting on the two halves with an equal force, but in opposite directions, are completely neutralized. In principle this method is simple and perfect; and in practice, with a model apparatus, consisting of a small table mounted on double gimbals and balanced, the correction is so complete that if the fixed frame be taken in the hand, and violently shaken, no vibration or particular disturbance is occasioned. But when a small weight is hung below, the least motion of the outside supporting-frame occasions a pertinacious oscillation of the internal gimbals carrying the table.

"*Elimination of Angular Movements.*—We have thus got rid of the effects of horizontal displacement, and of *lurching*, but the effect of angular motion still remains; for it will be found, on tilting the outside fixed frame above described, that the whole of the internal parts tilt over too, and have no power of themselves to maintain any one position more than another. The human hand is continually needed to put them right. When it is considered that a ship is never at rest, not even for the tenth part of a second, it is plain that we must look to some much more efficient means than the hand of man, to effect our purpose; something that will

in fact correct for the motion of the ship while it *is* taking place, and before it *has* taken place.

"*The Spinner, or Free Revolver Stand.*—On clearly making out to myself, two years ago, the nature of this difficulty, it occurred to me to try for its correction the principle that enables the earth so steadily to keep its pole pointed to one invariable part of the sky while it is being annually swung round the sun, and exposed to so many disturbing forces, which are yet not able sensibly to prevail against it. This principle, the persistence of a free axis of rotation, combined with the composition of rotatory motion, was also particularly known to me by Troughton's Top, or Spinning Pendulum, before alluded to, and by the writings of the Rev. Baden Powell.

"Introducing, therefore, into the internal gimbals of the already-described balanced apparatus, a smoothly and rapidly revolving wheel, and balancing it also on the gimbal pivots, and placing its plane horizontal, I had the satisfaction of finding that it was perfectly efficacious in defending the table from any pitching or rolling motion that could be given to its supporting frame, quick or slow, short or long.

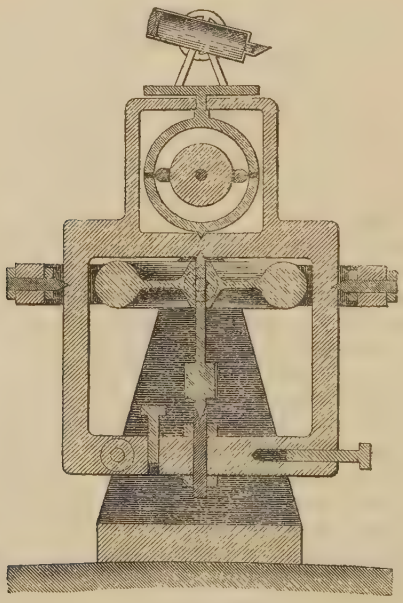


Fig. 3.

Sectional Elevation of Simple Revolver Stand.

"The single spinner apparatus described above, though fully able to protect from all disturbances at right angles to its plane,

cannot protect from any that coincide with it. But having, by its means, obtained a small platform, which, once put level by hand, keeps itself so, we may on that erect a second spinner in gimbals with its plane vertical; and balancing this on its own gimbals, and also on those of the first spinner, we may then employ its power to protect from azimuthal movements a table or a telescope placed on its outer gimbal ring.

"Such table will then be entirely defended from all the possible angular movements of a ship; and a telescope once directed on a star, will keep it in the field without hand, though the ship may pitch and roll and yaw to any extent. And if the telescope be moderate in size, and the eye-piece not far from the centre of motion, and its lens large, an observer would have no difficulty in following its apparent motions, with his eye, really rolling with the ship, and so might keep up uninterrupted observation with a high magnifying power.

"*Driving the Spinners.*—Having now a stand with wheels, and it being necessary to make them as large and heavy as possible, something more powerful than a train of wheel-work, impelled by the hand, is necessary to drive them, and to get up a speed, be it remembered, which is unprecedented in mechanics.

"Let it be laid down at once that our driving-power for the wheels must come from a steam-engine, by endless band, or by water, or by steam-pipe.

"With an endless band there will be difficulty in getting up the necessary speed, on account of the slowness of the first mover in a steam-engine. Intervening wheels and pinions multiply expense, vibration, and friction, and, after all, are not so extensively available for multiplying speed excessively as the motion of fluids pressed out of large tubes into small ones; as an extreme case of which may be taken the boiler of a steam-engine with some thousand times the area of the steam-pipe through which all the steam is conveyed away.

"This method I have therefore experimented on in the case of water, air, and steam. The same means employed to utilize one will also suit the others; but air and steam are capable of producing much more velocity than water for the same pressure; and of the two aëriform drivers, steam is the more easily applied, as it can be brought to bear at once out of the boiler by a pipe without the intervention of pump machinery. The steam indeed at first proved troublesome, by its heat and moisture, on escaping after it had done its work, but it was soon found quite possible to carry off all this waste by a second steam-pipe placed in a small wooden chimney communicating with the box in which the driving apparatus was contained.

"*Elemental Driving applied directly to the Spinner.*—To gain this end I have made many experiments, and have concluded with a small turbine on a pin which is fixed into the lower spinner pivot, and projects through its bearings. In the normal position of the apparatus the turbine hangs down in the inside of the sup-

porting-stand or table; the steam or water pipe, fitted with a peculiar nozzle, is then raised so as to enter the void centre of the turbine, and flashes out the fluid in a horizontal sheet through the curved and open sides. The vanes forming these sides are purposely set nearly at right angles to the radii, in order to make the speed of revolution surpass the rate of efflux, and appears in a transverse sectional plan, as in fig. 4.

Turbine Driver.
Sectional Plan.

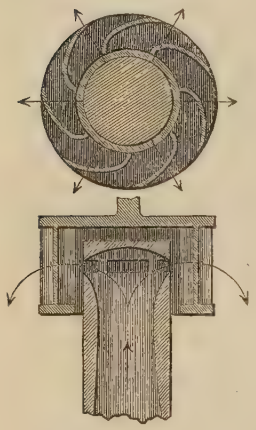


Fig. 4.
Sectional Elevation of the above.

"The power of this method is so great that the wheel moves the instant the steam is applied, the full velocity is obtained in but a few seconds, and the addition of the 10 lb. spinner hardly affects the rate of revolution of the 4 lb. turbine, which is about 70 to 80 per second.

"*Conclusion.*—With these powerful elemental methods of driving, and with large wheels at high velocities, there seems no reason why platforms should not be constructed for use on ship-board capable of carrying both the observer and his telescope.

"Tremor might be feared, because we find it more or less wherever we find mill-wheels revolving; but that is because their centre of gravity is not adjusted symmetrically to their axis of motion. In our case we do employ accurate methods of effecting this important correction, and we may expect, therefore, the large wheels to revolve as smoothly and as silently as the small ones."

The following paragraph appears in the *Boston Daily Evening Traveller* of October the 22d:—

"We understand that George P. Bond, Esq., who was recently appointed by the President, with the consent of the Senate, Chief Astronomer of the United States, under the Act of Congress of August 11th, 1856, to carry into effect the first article of the Treaty of June 10th, 1846, between the United States and Great Britain, by running the boundary line between America and British Oregon, has declined the appointment.

"Mr. Bond is the first assistant at the Astronomical Observatory of Harvard University at Cambridge, and by this decision meets the strongly expressed wishes of the friends of the Observatory, and of its Director.

"We also understand that this nomination was made by the

President, without any consultation with Mr. Bond, and solely on account of the high reputation he has acquired as an Astronomer. It was, therefore, an appointment equally honourable to the President and (to the) recipient thereof."

Extract of a letter from Mr. G. P. Bond, dated November 7, 1856:—

"We are preparing, on a large scale, for renewing experiments in lunar photography.

"Before this reaches you, you will probably have received Part i. of vol. i. of our *Annals*, completing the first volume . . . The subject of Part i. vol. ii. will be mostly *Saturn*, of which we have eight years' observations of physical aspect," &c.

At the conclusion of the ordinary business of the meeting, Mr. Carrington gave a verbal account of a recent short tour of inspection into the present state of some of the German observatories; premising his statement with the remark that it would greatly tend to keep our information of what other observers are engaged in up to date if other Fellows of the Society would, after autumn travels, in like manner communicate what they had had opportunities of ascertaining. The observatories visited were those at Bonn, Bilk, Göttingen, Gotha, Leipsic, Halle, Dessau, Berlin, Hamburgh, and Altona. Mr. Carrington was requested to put his remarks into a form suitable for the *Monthly Notices;* and will, in this paper, endeavour to comply with the wish expressed.

Woodcut representations of several of the above-named observatories will be found in a little tract entitled *Deutschland's Vorzüglichste Sternwarten*, written and published by Carl von Littrow, as an appendix to his Calendar for the year 1848, and sold separately. A copy was presented, and laid on the table.

At Bonn, Dr. Argelander, and his assistants, Drs. Schoenfeld and Kreuger, are now principally engaged upon a large series of zone observations of stars for basis-points of an extensive system of charting. The whole northern hemisphere has been divided into zones of two degrees width by one hour in length, to be gone over twice, the zones of the second series overlapping those of the first by one degree. The positions are being observed with a small equatoreal of less than three inches aperture, with a species of comb *painted* on a plate of glass in the focus; and the work is much of the quality of the Markree observations made with a similar object. Of about 2000 zones required, 1300 are completed, and a trial-chart (scale double the Berlin) lithographed. The Professor confines his own attention more particularly to the continuation of his researches connected with variable stars,

and to the measurement of double stars, with a very fine heliometer mounted in the principal central tower.

The observatory at Bilk was built in 1844, by a Dr. Benzenberg for his own use, and was at his death, about two years after, bequeathed to the town of Düsseldorf. Dr. Brünnow, now of Michigan, was stationed here for about three years, and on his return to Berlin at the end of the year 1851, was succeeded by the present Director, Dr. Luther. Dr. Luther is engaged in the observation and discovery of minor planets, preparing for publication one of the remaining charts of the Berlin Academy, filling in and extending Argelander's southern zones, and computing ephemerides. He possesses a very fine comet-seeker of five French inches aperture, provided with the so-called autoscopic eye-pieces, constructed by Kellner of Wetzlar, near Frankfort. These eye-pieces consist of three lenses, the first a large double convex lens placed before the focus, and the other two small, united with Canada balsam, and forming an object-glass combination. With a power of 15, the observer has a good field of four degrees. Kellner himself is now dead, and his widow carries on his business.

Books or communications of any size are most conveniently and rapidly received by Dr. Luther, if addressed in the first instance to Dr. Argelander; and the best mode of transmission to Bonn is through Mr. Otto Marcus, bookseller, of 8 Oxford Street, London, whose father is one of the principal booksellers in Bonn.

At Göttingen, Dr. Klinkerfues continues to be the resident astronomer; Professor Dirichlet, the geometer, having succeeded Gauss as director. One of the instruments here has now principally a historical interest,—the quadrant of Tobias Mayer. The chief instrument in use is a Reichenbach meridian-circle, employed on a partial revision of Piazzi's Catalogue; the instrument most used, perhaps, being the comet-seeker with which Dr. Klinkerfues has already discovered five comets.

The channel of transmission to Göttingen is through a London foreign bookseller to the firm of Dietrich.

One principal object in the writer's visit to Göttingen was to obtain a sight of the MSS. in which are contained Dr. S. T. Sœmmering's observations of the solar spots; but, after a search, in which he was much assisted by Mr. Wagner and Professor Listing, he found that he was under a wrong impression, and succeeded in tracing them to the Senkenberg institution at Frankfort.

At Gotha, a new observatory in the south suburbs of the town is in progress of erection, which is designed to take the place of the former one on the Seeberg hill, about a mile to the south-east. The Seeberg Observatory has been pulled down, and its materials have been used in the construction of the new one. The instruments are meanwhile placed in a small building attached to the dwelling-house of Professor Hansen, where Mr. Carrington was permitted to examine a modification of the method of circle-reading and provision for the determination of division-errors proposed by Professor Hansen in Nos. 388 and 389 of the *Astronomische Nachrichten*. Present

space does not permit the insertion here of a description of the arrangement adopted, but readers of German will find it repay them to refer to the article named, and will, perhaps, be the more induced to attend to the recommendation on being informed that Professor Peters has recently substituted this arrangement for that which was before in use at Altona, and that a transit-circle for Albany, now in the hands of Pistor and Martins, is likewise being so fitted. The lunar tables on which the Professor has been so long engaged had very recently been finished and forwarded to England for publication.

In another part of the town of Gotha was a private observatory belonging to Professor Habicht, provided with the usual transit and equatoreal; and, in addition, with one of Repsold's universal instruments. These small instruments are capable of doing very delicate work in skilful hands, are moderate in cost (40*l.* to 60*l.*), and from their adaptability to a variety of purposes, are, perhaps, better suited than any others for the introduction of students to the first leading processes of practical astronomy.

The observatory at Leipsic is probably the most singularly situated of any now existing. In the south-west angle of the fortifications of the city there is an extensive barrack, from which rises a cylindrical tower, of more than 150 feet in height, of about 40 feet interior diameter, and with walls of 10 feet in thickness, termed the Tower of the Schloss Pleissenburg. At a height of some 120 feet, the tower contracts on the outside, leaving a railed balcony of about 5 feet in width, and from thence rises in the form of a dome, surmounted by a lantern. At the level of the balcony, narrow sheds have been built on to the side of the tower for a transit and other instruments; and the telescope with which Professor D'Arrest has made his observations of nebulæ and comets, is mounted on a tripod, which is run out on wheels to any part of the balcony required, the ring-micrometer being of necessity used in all cases. Professor D'Arrest stated, that a removal was contemplated to a more suitable and less elevated situation in the outskirts of the city. A notice of some of the recent labours of Professor D'Arrest will be found elsewhere in the present number.

At Halle there is a small observatory situated in the Botanical Garden, consisting of an octagonal tower of three stories, provided with balconies, and, adjoining it, on the ground-floor, is a moderate-sized meridian-room. The transit-circle was at the maker's, undergoing repairs. The instrument for more general use is a Fraunhofer telescope of 52 lines ($4\frac{1}{2}$ inches) aperture, on a tripod stand; but for this Professor Rosenberger remarked that the building afforded no sufficiently firm support.

At Dessau, Mr. Carrington paid a visit to the Hofrath Schwabe, whose house is situated in the St. Johannis-Strasse. The observatory, for so it may be rightly termed, consists of a small attic, some 12 feet by 10, with four small windows overlooking the roofs of adjoining houses. From this little room a Fraunhofer

telescope, equatoreally mounted at one of the south windows, has, for thirty-one years, been almost daily directed to the sun, and by its means the spots observed on its surface have been recorded regularly in a series of quarto volumes, with appended diagrams, which now form a considerable collection, and one which excites no little interest in the beholder from the singleness of aim, continuity of purpose, and success with which their author has laboured upon them. Mr. Schwabe is now sixty-seven years of age, and still continues his accustomed occupation.

A full description of the Observatory at Berlin, with plans, is given in the first volume of Professor Encke's *Observations*. The writer was principally struck with the large refractor, mounted in Fraunhofer's manner, and with the perfection of the shutter-machinery in the meridian-room. Professor Encke is assisted at the present time by Dr. Forster and Mr. Carl Bruhns, who find the observation of the minor planets and comets with the great refractor as much as their united force can profitably be extended to.

At Hamburgh, a new equatoreal tower of considerable dimensions is nearly completed. It stands in the rear of the dwelling-house, and detached from it. The interior diameter of the dome, which is of metal, is 20 feet clear. The instrument is not yet constructed, but it is intrusted to Mr. Repsold, and intended to exceed 9 inches in aperture. When mounted, it will be the principal instrument of the Observatory. At present, Mr. George Rümker is engaged in observing the minor planets with the equatoreal so long used by his father; who, since his severe accident, has been unable to take any further active part in the work of the Observatory.

At Altona, Professor Peters has been introducing the use of Hansen's auxiliary sectors and moveable microscope-frame in the reading of the transit-circle, raising the equatoreal tower to obtain a better horizon, and building a set of rooms adjoining his own house for the residence of his assistant, M. Pape. In other respects the Observatory and grounds presented nearly the same appearance which they did during a former visit, in the year 1851, to the late Professor Petersen. Professor Peters was intending to apply the meridian-instrument, in the next place, to the determination of the positions of a limited number of circumpolar stars. Astronomers know what to expect in that case from this consummate manipulator and analyst.

Book-parcels may generally be forwarded directly to Gotha through a foreign bookseller; otherwise, for Gotha, Leipsic, and Halle, the Weidmannsche Buchhandlung at Leipsic is the best centre of delivery.

Similar parcels for Hamburgh and Altona are best sent by the same channel to Messrs. Perthes, Besser, and Mauke of Hamburgh, with whom both Observatories have dealings.

All requisite information concerning letter postage for the above, and probably all other Observatories, may now be found

in sections 7 and 9 of the *British Postal Guide*, lately published by the authority of the Postmaster-General.

Mr. Carrington has, in the foregoing sketch, abstained from all allusion in passing to an inspection of the large Bürger-schule of Leipsic, which he was most kindly allowed to make by their present learned Director, Dr. C. Vogel, the father of Dr. Edward Vogel, now travelling in Africa; to a visit of a like nature to Mr. Repsold's factory in Hamburgh; as well as to an interview with the Baron von Humboldt, which he had the high honour and gratification to be favoured with at Potsdam. He fears, on reviewing what he has written, that, in the attempt at extreme condensation, much matter of interest has necessarily been boiled away; but he trusts that readers of the paper will allow that it is simply impossible to give an adequate description of nearly a dozen different establishments in the compass prescribed.

Much information of a like nature, concerning the present American Observatories, with the advantage of woodcut illustrations, will be found in the *third* edition (recently published) of Professor Loomis's *Recent Progress of Astronomy, especially in the United States.*

The attention of the Fellows is called to a small octavo volume of 110 pages, by Mr. J. F. Julius Schmidt, entitled *Das Zodiacallicht.* In this work Mr. Schmidt gives numerous observations of estimated right ascensions and declinations of points in the north and south bounding lines of the cone of light, as seen by him at different times during the years 1843 to 1855. The first section contains a notice of the labours of his predecessors in the subject. The second contains the observations and accompanying remarks, arranged chronologically. The third contains the equivalents of the preceding observations, converted into latitude and longitude, for intervals of 10° or 20° longitude, after removing surface discordances by a process of curving and interpolation. In this section the data are arranged in the order of months and days, without regard to the year. Mr. Schmidt then proceeds to a discussion of his results, assembling them first for that purpose into eight groups, with a mean date. He finds a variation in the inclination of the axis of the cone of light to the ecliptic, from 4° 18′ at the end of December to zero towards the end of March; a similar variation in the greatest elongation from the sun, from 120° in January to 70° in April; and a further similar variation in the breadth at corresponding elongations: the totality indicating a minimum for all three at about the 30th of March. By continuing backwards to the longitude of the sun the north and south bounding lines of each day's observation, he finds a mean breadth at that part of about 50 times the sun's diameter. The fourth and last section is devoted to an inquiry into the possible connexion of the phenomenon with the resisting medium round

the sun. We do not aim to do more than give an idea of the contents of Mr. Schmidt's little book, leaving it to those who have paid more attention to the subject to say what degree of reliance can be placed on results of this nature; but we are very glad to see systematic observation and careful induction brought to bear on this field of inquiry.

Another work which we have to notice is the first series by Professor D'Arrest of his *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen*, published in the *Transactions* of the Royal Society of Saxony. This work contains about 600 observations of 230 nebulæ, made with a double-ring micrometer of Fraunhofer's construction, applied to a refracting telescope of 52 lines aperture, or rather more than $4\frac{1}{2}$ English inches. Professor D'Arrest states in his preface, that he considered it would not be a superfluous undertaking to lay a basis for subsequent inquiry into the possible relative motion of the nebulæ and fixed stars, by connecting them by observation at the present time with stars from the zones of Bessel and Argelander. He remarks that he has been astonished to find, as his work proceeded, how large a number (probably nearly a thousand) of these objects were within the reach of his very moderate-sized instrument. His plan has been to make repeated observations in as many cases as possible of the nebulæ admitted into his list, and to confront them with the older positions, brought up to date, of Lacaille, Messier, Mechain, Oriani, the two Herschels, and Laugier. Of new nebulæ he has met with only three or four, of which not more than two could be classed among the brighter ones. He proceeds to an inquiry into the comparative errors of individual observations of the older authorities, and then into the probable errors of his own results, and concludes with stating that, although in two or three cases there appear differences of sensible amount between the ancient and modern observations, the differences are so few and moderate that they may rather be attributed to some error in the older observation. A catalogue of Sir W. Herschel's nebulæ of the first and fourth classes, brought up to 1850, is given at the end.

Star-Charts.

The Society has recently received, from the Imperial Observatory at Paris, the first six numbers of a series of seventy-two Ecliptic Charts, laid down by M. Chacornac. The scale is about $2\frac{1}{4}$ English inches to the degree, or rather more than four times that of the Berlin Academy Star-charts. They are filled in to the thirteenth magnitude, and the relative magnitudes are distinguished by the size of the dot denoting the position. The date of the last comparison of each chart with the heavens is added,

a practice which we recommend for adoption. The engraving and general execution is singularly beautiful, and we should not fear to hold them up as a model of representation for the imitation of others engaged in the like work.

A second edition of Harding's *Atlas* has lately appeared, under the editorship of Dr. Jahn. It is stated in the title that the maps have been much improved by the assistance of several astronomers, which will doubtless give them an increased value to the observer. The price of the maps in London is 2*l.* 5*s.*

There has also been recently published a single sheet, about 8 feet in length by 2 feet in width, entitled *Die Æquatorialzone des gestirnten Himmels, entworfen von Prof. Dr. J. Müller* (*Freiburg, Fr. Wagnersche Buchhandlung*), on which the stars visible to the naked eye within the zone from 50° north to 40° south declination, are laid down in white on a dark purple ground. The boundaries of the constellations are marked with dotted red lines. The price is trifling, 4*s.* This sheet may be found useful for the lecture-room, and very possibly for something more.

A drawing of *Mars*, by Mr. R. Hodgson, was exhibited, which confirms the observations of Mr. De La Rue and Capt. Jacob.

Mr. J. G. Barclay has sent a drawing of *Mars*, made in April 1856, and two drawings of *Jupiter*, for Nov. 21, 1856.

The Astronomer Royal, who at all times evinces an earnest desire to smooth the difficulties of the astronomical inquirer, has placed a liberal supply of copies of the Results of the Greenwich Observations at the disposal of the Fellows.

Mr. Hind, the Superintendent of the *Nautical Almanac*, has also sent several copies of the Ephemerides of the Minor Planets for 1857, for distribution among the Fellows. Application to be made to Mr. Williams, the Assistant-Secretary, at the Apartments of the Society.

ERRATA.

Vol. XVI., p. 128, *Polyhymnia*, Jan. 15 / Feb. 12 } *dele* the results.

The Planet was not observed.

Vol. XVII., page 2, line 3, *for* $4^h\,22^m\,26^s{\cdot}9$, *read* $4^h\,42^m\,26^s{\cdot}9$.

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